4.—The Subterranean Freshwater Fauna of Yardie Creek Station, North West Cape, Western Australia

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The fauna of the wells of Yardie Creek Station consists of four species: a Synbranchid eel which is described and named in this paper, the Eleotrid fish *Milyeringa veritas*, and two species of Atyid shrimps. All these species show the usual characters of cave fauna: loss of eyes and of pigment. The fact that all species represent endemic genera suggests a considerable antiquity of this fauna. A discussion of the geology of the area is given, but no conclusion as regards the actual age of the fauna is reached.

Historical Review and Introduction

The occurrence of a specialised subterranean freshwater fauna at North West Cape was first made known by Whitley (1945). In October 1944, Mr. Whitley visited Yardie Creek Station, and was told by the station owner, Mr. E. Payne, of the occurrence of blind fishes in the Milyering Well, one of the wells on the station. Mr. Whitley and Mr. Payne paid a visit to the well, and Mr. Payne climbed down into it and managed to scoop up in his hat one specimen out of about a dozen present at the time. Subsequently this specimen became the type of *Milyeringa veritas* Whitley.

Whitley (1945) gave some particulars about the Milyering Well, and suggested that a subterranean river might seep through its limestone walls. In subsequent years Whitley mentioned the species *Milyeringa veritas* a few times in publications, and in recent years additional specimens were received by the Western Australian Museum. Some years ago live specimens were on show in the annual Wildlife Show in Perth, organised by the Western Australian Naturalists' Club.

Nothing essential was added to knowledge of this subterranean fauna until 1958 when Mr. Alf Snell, who had visited Yardie Creek Station as maintenance man of a shearing team, found amongst a sample of *Milyeringa's* he had collected some shrimps. He presented these to the Australian Museum, Sydney, whence they were forwarded for identification to Dr. L. B. Holthuis of the Leiden Museum (cf. Anon. 1959). Additional specimens collected by Mr. Snell in May 1959, were donated to the Western Australian Museum, and were also sent to Dr. Holthuis.

During one of his visits to the Western Australian Museum Mr. Snell also mentioned the observation of "blind" eels in one of the wells at Yardie Creek Station, of which, notwithstanding many efforts, he had not managed to catch a specimen.

It was mainly with a view to obtaining material of this eel, but also to get larger series of the known animals and to gain a general idea about their habitat, that from the end of July 1959 onwards Mr. A. M. Douglas and I spent ten days on Yardie Creek Station. The results of this stay were satisfactory, a specimen of the eel was obtained, and series of shrimps and *Milyeringa veritas*. Besides, collections of birds, reptiles, and insects were made.

In May 1960 another short visit was made and, thanks to Mr. Douglas's nocturnal activity, a second eel was collected.

In the meantime Holthuis (1960) described the shrimps, which he found to belong to two different, but related species. Hence, the fauna of the wells, as at present known, consists of four species: two shrimps, a goby and an eel. Though one must always remain prepared for surprises, I consider it unlikely that more species occur and believe that the macrofauna of these subterranean waters is now completely known.

In this paper, besides descriptions and notes on observations, the results of investigations into the following three problems are given:—

1. How long has the habitat where this fauna is found been in existence?
2. How different, morphologically, are the cave forms from their presumed ancestors living outside the caves?
3. What are the chemical and physical properties of the habitat?

A correct answer to these questions would mean a knowledge of how long it has taken the cave fauna to develop from its presumably eyed ancestors into what it is now, in other words, of the speed of evolution, or better, morphological change, that has occurred under these very specialised conditions. It is perhaps as well to add here that I have failed because no certainty could be obtained that this fauna has evolved in the place where it is now living.

Description of Habitat

The area under discussion is the north-western part of the North West Cape Peninsula (Fig. 1). The Cape Range, which reaches up to the lighthouse at Vlaming Head, forms the backbone of the peninsula. On the outside of the range is a platform of between 1½ and 3 km wide, and along the sea coast is a narrow line of sand dunes. It is evident that on many places fresh sand has been blown quite recently over the older coastal platform.

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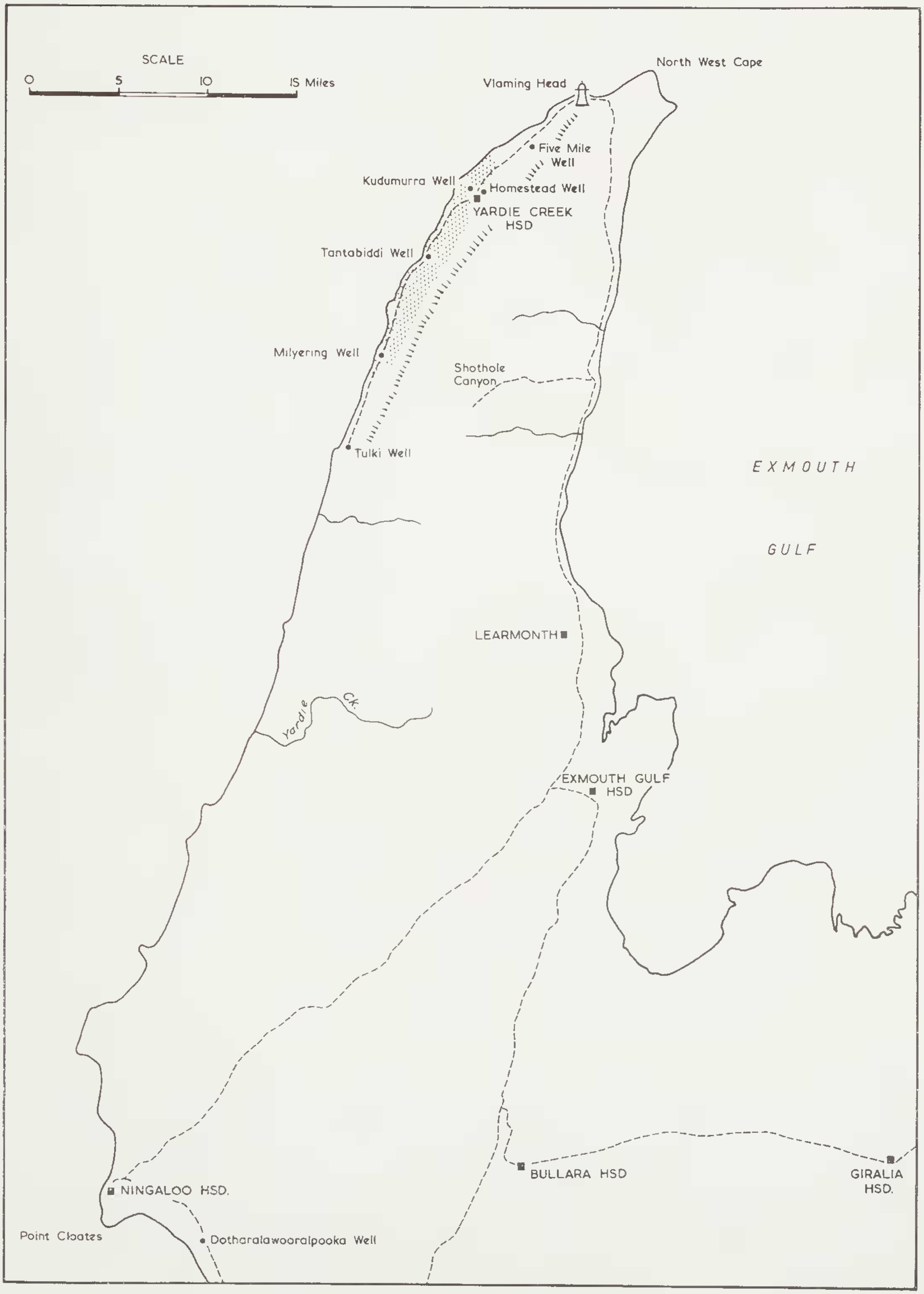

Fig. 1.—Map of the North West Cape Peninsula. The area in which the subterranean fauna is known to occur is dotted.

It is this coastal plain or platform that is of interest, because that is where the wells are sunk. The whole platform is very flat and stony, and in many places small and shallow sink holes occur which show, as do the artificial wells, that the base of this plain consists of almost pure coral rock, brownish white in colour, mixed with fossil shells, etc. The surface of the platform is about two metres above water level.

This whole layer of coral rock is apparently traversed by crevices, small holes, and connecting corridors so that an extensive subterranean network of waterways exists, which forms the habitat of the fauna under discussion. More arguments for regarding the structure as this, and not, for example, as a subterranean river (as Whitley 1945, thought), follow below.

The platform extends along the whole outside of the peninsula, but to the south I have only been as far as the Tulki Well, and I do not know if the structure farther south is identical. However, there is a length of at least fifteen miles of coral-rock platform.

In this platform, at distances of five miles apart, sheep wells have been sunk, which are, from north to south: Five Mile Well (Chugorie Well on the Admiralty Chart), Kudumurra Well and Homestead Well (these two are only a few hundred metres apart), Tantabiddi Well, Milyering Well, Tulki Well*. Holthuis's statement that the Milyering and Kudumurra Wells are 20 miles apart is a slip, for their actual distance is 10 miles.

We visited and climbed down all these wells, but only in three of them cave fauna was found, and descriptions of these three follow here.

The Milyering Well (Fig. 2) is hacked out in the coral stone; the upper rim is cemented, but lower down the coral stone was apparently considered solid enough by the builders and remains uncovered. This makes climbing down easy because everywhere there are small dents and holes in the sides which allow one to get a good grip. Normally the well is covered by a few sheets of corrugated iron. Though the cemented rim has a diameter of not over a metre, lower down the well is somewhat wider. The water surface is about two metres down, and the water in the well is not over about 50 cm deep, on a cup-shaped bottom. But in the sides of the walls, on and just below the water surface, are some crevices, water channels, the places through which visiting *Milyeringa's* enter and leave the well.

A mill is on top of the well, and pumps the water in a biggish reservoir from where two pipes lead on to two drinking troughs. The water is very tasteless, which is partly caused by the high temperature, and partly by a fairly high salinity (slightly brackish). The temperature, measured several times a day in the first week of August, 1959, and again on 16th May, 1960, was about 27° C.

Fig. 2.—Mr. Douglas at the Milyering Well. 16.V.1960. Note the numerous blocks and pieces of coral stone that cover the platform.

A further discussion, viz. of the water movements and of the composition of the mud on the bottom follows after.

The Tantabiddi Well is a natural cavity that either was already open, or of which part of the roof has been removed. Now it is a little pool with several square metres of water surface, partly vaulted over. In two directions one sees deep tunnels or shafts, which, however, lead upwards, and therefore are dry and cannot be used by aquatic animals. The pool has a greatest depth of about half a metre and the bottom is covered with mud. There are no open connecting channels; this is important in connection with the distribution of the fauna as I shall explain later on. There is the usual Southern Cross windmill which, however, is not straight above the waterhole, but some little distance away. Probably because of its being open, the temperature of the water is slightly lower than in the other wells, about 24° C. in the first week of August, 1959. As the analysis (Table I) shows, the water is definitely less brackish than that of the Milyering Well, which is doubtless caused by the fact that rainwater has free access to this well.

The Kudumurra Well is the most prosaic looking of the three, as it is entirely cemented. The water-level is at about 1.75 m depth, and about 20 cm lower down the cemented tube

* The Kudumurra Well is called Kurumuru Well on the Admiralty Chart No. 3187: Mangrove Islands to North West Cape, new ed. 1915. Kurumuru may well be the more correct spelling, but the people who gave these names have gone for ever and their meaning has been forgotten.

which forms the well ends, and rests on some horizontal wooden joists. The water is not over 50 cm deep and, just as in the Milyering Well, crevices and channels seem to run in various directions. The Southern Cross windmill is not above the well, but at its side, some metres away. Inscriptions on the rims of this and other wells show that they were constructed in 1913, and not in the early 1920's as Whitley (1945) would have it. The temperature of the water in this well, in August, 1959, was 29-30° C (84-86° F), on 17th May, 1960, it was 28.3° C (83° F).

TABLE I

Certificate of Analysis

Date received: 1st September, 1959.

Result of Analysis:

Marks:	Tantabiddi Well	Milyering Well
Reaction	Neutral	Neutral
pH	7.5	7.1
Mineral Matter		*Parts per million*
Calcium, Ca	113	126
Magnesium, Mg	141	188
Sodium, Na	999	1414
Potassium, K	36	53
Bicarbonate, HCO_3	336	316
Carbonate, CO_3	nil	nil
Sulphate, SO_4	240	358
Chloride, Cl	1810	2550
Nitrate, NO_3	3	3
Silica, SiO_2	15	11
Iron oxide, Fe_2O_3	less than 0.1	less than 0.1
Aluminium oxide, Al_2O_3	5	10
Phosphate, PO_4	0.4	0.2
	3698	5029
Assumed combination on evaporation at N.T.P.		
Calcium carbonate, $CaCO_3$	276	259
Magnesium carbonate, $MgCO_3$	nil	nil
Sodium carbonate, Na_2CO_3	nil	nil
Calcium sulphate, $CaSO_4$	9	75
Magnesium sulphate, $MgSO_4$	293	382
Sodium sulphate, Na_2SO_4	nil	nil
Magnesium chloride, $MgCl_2$	320	434
Potassium chloride, KCl	69	101
Sodium chloride, NaCl	2537	3592
Sodium nitrate, $NaNO_3$	4	4
Hardness calculated as calcium carbonate.		
Total hardness	862	1089
Bicarbonate (temporary) hardness	276	259
Non-carbonate (permanent) hardness	586	830
Calcium hardness	282	315
Magnesium hardness	580	774

Sgd. R. C. GORMAN,
Deputy Government Agricultural Chemist.

Water samples were taken from all three wells, but the bottle from the Kudumurra Well unfortunately lost its contents on the way down to Perth. The result of a very full analysis of the water of the other wells is given in Table I.

There is no trace of current in the water of any of the wells, which supports my opinion of the nature of the subterranean water.

It is interesting that all three wells show tidal movements; the water moves up and down about 15 cm each day. According to my geologist friends this does not necessarily mean that an open subterranean connection with the sea exists, but rather that there are permeable layers of sand, etc., which allow the tidal influences to be felt some way inland.

The mud on the bottom of all three wells is very rich in organic matter. Particularly the Milyering Well and the Kudumurra Well, both of which are normally covered with sheets of iron, act as traps for all kinds of animals that seek shelter under the covering sheets. The first time I descended the Kudumurra Well, for example, I found a small python, *Liasis childreni*, swimming in it; if I had not saved it it would doubtless have died and added to the nutritive value of the debris at the bottom. In the mud of this same well I found bones and teeth of small mammals, and in all the wells great numbers of exoskeletons of woodlice. Woodlice live in some numbers under the covers of the wells, and fall in the water regularly.

It is likely that, because of these favourable factors, the concentration of fish and shrimps in the wells is greater than it is elsewhere in their subterranean domain.

Fauna

Family SYNBRANCHIDAE

Anommatophasma genus novum*

Superficially very similar to the eel from Hoctun Cave near Chichen Itza, Yucatan, described by Hubbs (1938) as *Pluto infernalis*, hence to the genus *Synbranchus*, but differs from that species as well as from all other members of the suborder Synbranchoidei by the position of the anus, which is in the anterior half of the body.

Type species:

Anommatophasma candidum species nova

A slender Synbranchid adapted to life in total darkness in caves. Head comparatively short, its height about half its length; upper surface of head behind snout swollen, with a shallow longitudinal groove in the middle; head deeper than any other part of the body and therefore fairly well defined; mouth comparatively large, cleft in lateral view about two-fifths of length of head; lips thick, especially anteriorly; teeth fairly strong, laterally in both jaws in a single row, anteriorly in a band of three or four rows deep; a narrow band of teeth, parallel to the jaws, on a ridge on each side of the palate; tongue well developed, anteriorly free and rounded to slightly truncate, without teeth; one pair of very small nostrils at the tip of the snout in the upper lip, a second much larger pair of nostrils on upper surface of snout just before elevation of forehead, roundish, each one covered by a dermal flap that is attached on its anterio-lateral rim; eyes absent, but anterioventrally of the second pair of nostrils is a subcutaneous concentration of what appears to be nerve tissue, and which may well represent vestiges of eyes; several pairs of mucous pores are present on the head but they are difficult to see, one fairly conspicuous pair is on the snout half way between the first and the second pair of nostrils; throat with some longitudinal dermal folds; gill opening rather wide, transverse, the covering skin lunate in shape; four pairs of gills, well developed; body long and

* From ανομματος = without eyes, and φασμα = apparition, phantom.

slender, roundish, the last few centimetres of the tail compressed; anus in anterior half of the body; lateral line distinct and continuous to near the tip of the tail, but I have been unable to find pores in it; no fins except a thin rayless fin membrane near and round the tip of the tail, in which I have been unable to detect even the vestiges of rays, but at the tip of the tail four or five hypurals are present.

Material. Two specimens.

P 4917 Tantabiddi Well, Yardie Creek Station, North West Cape, 31.VII.1959. Type.
Total length 370 mm, length of head and body (to anus) 150 mm, length of head from tip of snout to gill opening 20 mm, cleft of mouth from tip of snout to posterior border of maxilla 9½ mm.

P 4918 Tantabiddi Well, Yardie Creek Station, North West Cape, 17.V.1960.
Total length 316 mm, length of head and body (to anus) 121 mm, length of head from tip of snout to gill opening 16½ mm; cleft of mouth from tip of snout to posterior border of maxilla 7 mm.

Colour. The colour in life is a very striking pure white. In a captured specimen we noticed that in some parts a faint pinkish tone appeared that was not originally present; presumably this was caused by damage of small bloodvessels as a result of its capture. Microscopic examination revealed the presence of dispersed pigment in the skin which is irregularly but more or less evenly distributed over the whole body and does not show any particular pattern.

Abundance. Besides the Tantabiddi Well, where our two specimens were obtained, one example was observed in the Milyering Well. Though we have not seen specimens in the Kudumurra Well the species has been reported to occur there by one of the stationhands. The limited number of observations conclusively shows that this eel is far less plentiful than *Milyeringa* though there is no reason to regard it as particularly rare.

The explanation of the fact that in the Tantabiddi Well only eels were found, and no other cave fauna, is probably that this well, contrary to the other two wells, has no open connections with subterranean waters. Such connections as exist are filled with mud and debris, through which the eels are able to move, but not the free-swimming *Milyeringa's* and shrimps.

Discussion. From the preceding description it will be clear that in all characters, except those which are evidently connected with life in darkness and which it shares with *S. infernalis**, this species fits very well in the genus *Synbranchus*, but for the anterior position of the anus.

The position of the anus in the Synbranchiformes has hitherto been regarded as of great systematic importance, but it seems now that the value of this character has been overestimated. Reference to the position of the anus in the diagnosis of the suborder Synbranchoidei as given by Regan (1912) and of the family Synbranchidae as given by Weber & de Beaufort (1916), to mention but a few authors, should be eliminated. It is interesting to note that Berg (1955) did not mention the position of the vent in the diagnoses of any of the subdivisions of the order.

On the other hand, it seems unlikely that the anterior position of the anus in *Anommatophasma* would be advantageous in cave life, hence be adaptive (more about this will be said in the section on convergence and nomenclature). Perhaps, however, food conditions and the predator-free cave life may have been responsible for a shortening of the digestive tract. Anatomical work and a study of feeding habits and food may in future cast new light on this problem. Until these points have been cleared I feel perfectly justified in attaching generic importance to the character. This point of view finds mild support in the fact that both the other fish and the shrimps inhabiting this habitat have developed into indigenous genera.

As far as the relationships of *Anommatophasma candidum* are concerned, the obvious species to consider is *Synbranchus bengalensis* (McClelland), which is the only other Synbranchid eel known to occur in Western Australia*.

The genus *Synbranchus* is in need of a revision, and the various nominal species are very similar to each other. I have compared specimens of *S. marmoratus* and *S. bengalensis* and found that *S. marmoratus* apparently differs from *S. bengalensis* by having a much narrower gill-opening which is concealed in longitudinal skin-folds, in having relatively larger eyes, and more vertebrae. One specimen, however, is very near *S. bengalensis* but differs by having a slightly larger number of vertebrae; the anus is slightly more posterior in position*. *Anommatophasma* has a wide gill-slit, as has *S. bengalensis*, but unfortunately *S. infernalis* has, as Hubbs's figure shows, also a wide slit though it is supposed to have been derived from *S. marmoratus*.

* Reasons for placing "*Pluto*" *infernalis* in the genus *Synbranchus* are given in a later section of this paper.

* Whitley (1948, 1960) has resurrected the name *Synbranchus gutturalis* Richardson for specimens from Australia. As he has apparently never given reasons for this I do not follow him. I do not belong to that group of zoologists who regard the mere fact of the occurrence of an animal in Australia in itself as sufficient reason to separate it nomenclaturally.

* This specimen bears on its label the name *Synbranchus chilensis*, Chili, Frank 1849, R.M.N.H. no. 3899. *S. chilensis* is apparently a manuscript name that has never been published. The only *Synbranchus* at present known from the west coast of South America is *S. marmoratus* which, however, has not been recorded from Chili, Peru being its known southern limit. In view of the somewhat obscure origin of the specimen (localities supplied by dealers are notoriously untrustworthy; as far as Frank is concerned, see Gijzen 1938, p. 180), it seems best not to attach much importance to this. Though the specimen seems to show some slight differences from *S. marmoratus*, the fact that it has the same number of vertebrae points to its belonging to that species. The mention of the name *S. chilensis* in this discussion must not be interpreted as a validation of this name for use in zoological nomenclature (cf. Copenhagen Decisions on Zoological Nomenclature, 1953, p. 63, § 114).

The differences in position of the anus between *Synbranchus* and *A. candidum* are quite striking:

S. marmoratus ("*chilensis*"),
preanal length: postanal length 10 : 3

S. marmoratus,
preanal length: postanal length 8 : 3

S. bengalensis,
preanal length: postanal length 8 : 3

A. candidum,
preanal length: postanal length 2 : 3

Some of the specimens were X-rayed. The number of vertebrae as counted from X-ray photographs is:

	body	tail	total
S. marmoratus (R.M.N.H. no. 3899)	84	+c.54	c.138
S. marmoratus (R.M.N.H. no. 16352)	87	+ 48+	135+ (tip of tail damaged)
S. bengalensis (R.M.N.H. no. 7146)	75	+ 54	129
S. bengalensis (same regd. no.)	77	+c.53	c.130
A. candidum (W.A.M. no. P 4917)	51	+ 111	162
A. candidum (W.A.M. no. P 4918)	54	+ 109	163

These figures show that the number of vertebrae is a useful systematic character in the group. Because I have been unable to examine this character in all species of the genus *Synbranchus* and related genera, I have not mentioned the large number of vertebrae of *Anommatophasma* in the diagnosis of that genus though I note that according to Regan (1912) *Synbranchus* has 127-137 vertebrae. It is clear, however, that *A. candidum* differs from the species of *Synbranchus* that were examined both in having a decreased number of vertebrae in the body and an increased number in the tail.

The description of *Typhlosynbranchus boueti* Pellegrin (1922) shows that in one respect, the presence of only three pairs of gills, that genus is more different from *Synbranchus* than is *Anommatophasma*, but it has the anus in the posterior third of the body. From *Anommatophasma* it further differs by the strong pigmentation and the small gill-opening.

Comparison of *Anommatophasma* with other genera of the Synbranchidae is superfluous.

Family ELEOTRIDAE

Milyeringa veritas Whitley

Milyeringa veritas Whitley, Aust. Zool. 11, 1945, p. 36, Fig. 15—Milyering, Yardie, 20 miles south-west of Vlamingh Head, North West Cape, Western Australia.

Milyeringa; Whitley, Aust. Zool. 11, 1947 (June 20), p. 146 (Western Australia); Whitley, in: Biogeogr. Ecol. Aust., 1959, p. 142, 146 (Fig. 3 no. 34), 147 (in a well in the North West Cape area); Holthuis, Crustaceana 1, 1960, p. 48 (Kudumurra Well).

Milyeringa veritas; Whitley, W. Aust. Nat. 1, 1947 (Dec. 15), p. 53 (Greyian Fluvifaunula); Whitley, W. Aust. Fish. Dept., Fish. Bull. 2, 1948, p. 28 (Western Australia); Whitley, Aust. Mus. Mag. 10, 1951, p. 162 (Milyering); Whitley, Aust. Mus. Mag. 11, 1954, p. 151, 153, Fig. (north-western Australia); Whitley, Proc. Roy. Zool. Soc. N.S.W. 1954/55, 1956, p. 42 (Australia); Holthuis, Crustaceana 1, 1960 (Jan.), p. 47 (Milyering Well); Whitley, Nat. Freshw. Fish. Aust., 1960 (Nov.), p. 121 (North West Cape); Mees in Ann. Rep. W. Aust. Mus. 1959-60, 1961, p. 23 (North-west Cape); Ride & Serventy, in Little (editor): Off. Yearb. W. Aust. 1960, no. 2 (n.s.), 1961, p. 67 (wells and subterranean channels in the North West Cape area).

This curious goby was described and figured by Whitley, to whose notes I have little to add. Instead of D IV-9, A 9, it would be better to write D IV-8½, A 8½. The scales are reduced, and entirely absent from the head; there are about 28 rows in a longitudinal line. The variation in size in our series of about 50 specimens is from 30 mm to 42 mm in standard length.

Colour. Yellowish white in life and health. The brain is visible through the upper surface of the head as a more or less triangular dark patch. The fins are white as the rest of the body. The flesh colour of the fins recorded by Whitley (1945, 1960) must be due to the same cause referred to under *Anommatophasma candidum*. I have been unable to detect any pigment in the skin.

Abundance. At our arrival on 29th July, 1959, we found about half a dozen specimens of *Milyeringa veritas* in the Milyering Well. We caught them, and, as the well is fed by subterranean channels, the original number was gradually restored, so that during the afternoon and evening we could harvest several times. However, in my notes of 5th August, it is stated that, whereas on the first day every time about six specimens could be taken, now we did not find more than one or two during each visit. It is out of question that, by taking specimens from one single well, we would have been gradually depleting the whole population, but it does indicate that the fishes do not swim far or fast, that because of our activities they had become scarce in the near surroundings of the well, and that replenishment from more remote areas took place too slowly to counterbalance the influence of our collecting. On 16th May, 1960, the usual half-dozen was present again. Whitley (1945) stated that during his visit about a dozen specimens were present in the Milyering Well and that three times as many had been seen in the well, but we never found such large numbers.

In the Kudumurra Well the species is much scarcer, quite often no specimens at all were present, usually only one or two, and never more than three at a time. No specimens were ever observed in the Tantabiddi Well.

Discussion. When Whitley (1945) described *Milyeringa veritas*, he not only placed the species in a new genus, but also in a new family, though suggesting that it was: "perhaps evolved from some gudgeon similar to *Carassiops*, which is not known from Western Australia." Subsequently Whitley (1947) recorded *Carassiops compressus* from a well east of Carnarvon and added that: ". . . . they indicate the probable line of descent of the interesting Western Australian blind gudgeon, *Milyeringa* . . . ."

It should be remarked that the creation of a new family or other high systematic unit for a new species is about the cheapest way to escape from the trouble of finding its true affinities. In the present case one may wonder why a new family had to be established when Mr. Whitley already suggested that *Milyeringa* was derived from *Carassiops*; in other words, if the new genus *Milyeringa* can be said or is believed to be close to *Carassiops* and not to other genera of the Eleotridae, *Milyeringa* and *Carassiops* are evidently closer to each other than either is to other genera of the Eleotridae, and therefore *Milyeringa* can certainly not be separated from *Carassiops* as a different family.

The genus *Carassiops* is nowadays regarded as a synonym of *Hypseleotris* (cf. Koumans 1953, p. 324). As I wanted to have an expert opinion on the affinities of *Milyeringa*, some specimens were forwarded to Dr. Boeseman who gave me (in litt., 13.1.1960) as his opinion that the species *Milyeringa* is closest to *Prionobutis microps* (M. Weber). *Prionobutis* is a genus of Eleotrid fishes that is supposed to be not distantly related to "*Carassiops*." *Prionobutis (Pogoneleotris) microps* occurs in New Guinea and in north-western Australia (Daly River) in fresh and brackish water. The similarity in many respects is striking, according to Dr. Boeseman, and includes general shape, particularly shape of the head, D 1.8 or 9, A 1.8 or 9, C. c. 14, V 1.5, sc. c. 30, shape of mouth and tongue (rounded-truncate), dentition, papillae on snout, etc.

On the other hand, the differences between *Prionobutis* and *Milyeringa* are certainly large enough to keep the two genera separate. *Milyeringa* may or may not have been derived from *Prionobutis*, at present it is morphologically sufficiently different to be regarded as a fairly well-marked separate genus.

Family ATYIDAE

Stygiocaris lancifera Holthuis

Stygiocaris lancifera Holthuis, Crustaceana 1, 1960, p. 48—Kudumurra Well, Yardie Creek Station, North West Cape Peninsula, W. Australia.

Stygiocaris lancifera; Mees in Ann. Rep. W. Aust. Mus. 1959-60, 1961, p. 23 (North-west Cape).

This species seems to be very much the commoner of the two, for the material sent to Dr. Holthuis consisted of 147 specimens of this species as against 15 of *S. stylifera*.

As the two species were not distinguished by me the following notes may apply to either of them, but doubtless mainly to *S. lancifera*. Shrimps were common in the Kudumurra Well, but scarce in the Milyering Well and not found in the Tantabiddi Well.

They are entirely colourless transparent, with the exception of the internal organs of the thorax, which show as a yellowish mass. The contents of the intestine is visible as a straight black stripe, but many specimens have the intestine empty.

In the Kudumurra Well I often observed shrimps. In daytime it was very difficult to see them, but at night in torchlight they were more visible. They appeared to be resting, probably also feeding, on the upper surface of the wooden joists, on the walls of the well, and also on the mud of the bottom. An occasional individual would swim round freely just under the water surface, possibly obtaining food from the surface film. There is no evidence that digging or rooting in mud takes place to any extent.

Stygiocaris stylifera Holthuis

Stygiocaris stylifera Holthuis, Crustaceana 1, 1960, p. 54—Kudumurra Well, Yardie Creek Station, North West Cape Peninsula.

Stygiocaris stylifera; Mees in Ann. Rep. W. Aust. Mus. 1959-60, 1961, p. 23 (North-west Cape).

As noted under the preceding species, the relative abundance of *S. stylifera* as opposed to *S. lancifera* is about 1 : 10 in the material collected. This slightly larger species seems therefore to be much less plentiful.

Geological Evidence

Largely as a preliminary to and a result of the recent intensive oil exploration in the region, the geological structure of the North West Cape Peninsula is well known (Condon, Johnstone & Perry 1953). The spine of the peninsula is formed by the Cape Range, the exposed parts of which are mainly of Tertiary age: these same authors state that the coastal platform is Recent, but they do not devote any particular attention to it.

To Dr. Logan (in litt., 16.IX.1959) I am greatly indebted for much additional information, most of which I quote verbatim:

> "I examined the plain along the western piedmont of the Cape Range some years ago, and I believe that it is a wave cut platform related to a former sea level of five to six feet above present mean sea level. In a few places in the area one can observe undercut pedestals or stacks of limestone standing above the level of the platform which exhibits most of the characteristics of the undercut on the shoreward periphery of the contemporary 'reef' flat which Fairbridge and others have described at Rottnest, Point Peron and elsewhere on the Western Australian coastline. The higher sea level stand at about two metres can be substantiated by emerged shell beds, coral reefs and wave cut platforms which occur at about two metres above present sea level in the Shark Bay area. Allowing for somewhat more tidal amplitude in the vicinity of N.W. Cape the Yardie platform can be well correlated with this level; meaning that the area along the foot of the Cape Range was inundated by the sea in sub-Recent times.
>
> Evidence all along the W.A. coastline and elsewhere in the world suggests a higher stand of sea level at about two metres above present due to eustatic causes (advance and retreat of the polar ice caps). The evidence for this eustatic sea level high is imposing and the constancy of the terrace level over wide stretches of coastline must tend to rule out local uplift as a genetic cause of this feature. One may expect slight variations in height due to local energy factors in the marine erosion of the coastline as differences in exposure to waves and tidal amplitude must inevitably cause slight variations in height of the platforms. I be-

lieve that the above explanation of the platform along the edge of the Cape Range is reasonable although one must be cautious for the Cape Range is a fold mountain which shows evidence for upwarping in the Pliocene, Pleistocene and possibly the Recent.

The two metre plus sea level stand of sub-Recent times has been dated in various parts of the globe by C14 dating techniques which gives ages of about 5,000 B.P.

The actual limestone outcrop along the foot of the Cape Range is similar lithologically to the Coastal Limestone along the western coast of W.A. between Geraldton and Dirk Hartogs Island; this is mainly an aeolian limestone formed by terrestrial agencies, and it dates from Pleistocene to Recent in geological age. Some of the platform may also be cut in Pliocene or Miocene limestones which occur on the flanks of the Cape Range . . . ."

The evidence that the coastal platform is not more than about 5,000 years old is quite conclusive and can be accepted without reservation. On the other hand, everything known about the speed of evolution or morphological change of animals points to its being a very slow process. Even under the extreme conditions under which the fauna under discussion lives, it is very hard to believe that morphological changes of a magnitude that demands generic separation from their presumed ancestors would have taken place in only 5,000 years. However, I quote a further paragraph from Dr. Logan's letter:

"As was found in the petroleum exploration of the Rough Range, the limestones in the N.W. Cape region are very cavernous down to about sea level, and it is not outside the bounds of possibility that the fauna developed and is living in these subterranean caverns which may have been connected to the sea at one time (for that matter they may still be in some connection) and the wells are now tapping water from these caves."

Therefore I regard it as likely that the subterranean fauna has developed in late Tertiary or in Pleistocene times, in what are now the hills, and that with the retreat of the sea during the last 5,000 years, and the subsequent emergence of the coastal platform and the decrease in salinity of the water, this fauna has been able to colonise the platform from the cavern systems in the hills.

Problems of Convergence and Nomenclature

Attention has already been drawn to the extraordinary similarity in general appearance between *Anommatophasma candidum* and *Synbranchus infernalis*.

However, whatever the true relationships between the two species may be—and the aberrant position of the anus in *Anommatophasma* suggests that they are only distantly related—it is likely that each of them has been derived from a different species of Synbranchid. Nevertheless, if morphological evidence only was considered, the two species would probably be regarded as very closely related. Yet, what we really have is convergence because it is fairly clear that *S. infernalis* has been derived from *S. marmoratus*, whereas the possible ancestor of *Anommatophasma* was *S. bengalensis*. When applying morphological criteria without historical considerations, "*Pluto*" *infernalis* and *Anommatophasma candidum* might well be united in one genus, and their respective ancestors in a different one. Hubbs was aware of the fact that his "*Pluto*" *infernalis* has been derived from *S. marmoratus*, and therefore is historically closer related to *S. marmoratus* than that species is to the other species of *Synbranchus*, but notwithstanding that, he allowed morphological facts to prevail when he created for his blind eel a new genus.

Of the conflict between historical relationship and morphological similarity in what we please to call the "natural system," most systematists are doubtless aware, and I do not see how it can ever be solved*. It seems appropriate, however, to draw attention to the fact that in our whole system authors use nearly always words like "affinity" and "relationship," for what is actually morphological similarity. Though the jargon has changed with the times, the method is still essentially the same as that used by Linnaeus and his contemporaries, two centuries ago.

Personally I believe that ideally in a natural system actual relationship should be expressed rather than morphological similarity, but I am well aware that only in a very few cases, as that of "*Pluto*," it is possible to distinguish between the two, and even when the distinction is clear, group names (families, genera, etc.) are applied in an arbitrary manner. For example, birds and mammals are probably closer related to certain orders of reptiles than the latter are to other orders of reptiles, yet we retain the classes Aves, Mammalia and Reptilia —to do other than adopt this arbitrary (but phylogenetically incorrect) procedure would lead to nomenclatural chaos. Therefore, subjective judgment in which historical knowledge (including the fossil record if available) is weighed against morphological criteria, will continue to be the basis of our system of classification.

It seems to me that Holthuis (1960) has not found a solution of the problem. In his diagnosis of the genus *Stygiocaris* he wrote:

"The genus is closely related to *Typhlopatsa* Holthuis from Madagascar . . . . . perhaps *Stygiocaris* should only be considered a subgenus of *Typhlopatsa*." I do not claim to have even the slightest knowledge of shrimps, and therefore am unable to evaluate their morphological characters. But I regard it as unlikely that blind shrimps from fresh water in Madagascar and blind shrimps from fresh water in Western Australia, separated by many hundreds of miles of ocean, would be nearer related to each other than either of them would be to some eyed species living along the coasts of Madagascar and Western Australia respectively. Instead of the words "closely related" Holthuis should have

* Of course I am aware of the existence of a large philosophical literature on the subject.

written "morphologically closest," for this morphological similarity may well be due to convergence.

Several times I have mentioned the fact that I regard certain characters as not of generic value because they are connected with life in darkness. This point of view is likely to meet with criticism because it may well be argued that any character is adaptive. However, most zoologists nowadays do not attach too much systematic significance to characters that are evidently connected with some particular way of life in animals that otherwise are morphologically close to other species. This would apply even more where a loss of characters is involved as a consequence of the absence of selective pressure for their retention.

It is on the basis of the preceding arguments that I prefer to place *"Pluto" infernalis* in the genus *Synbranchus*, so that the species should now be known as *Synbranchus infernalis* (Hubbs). The genera *Pluto* Hubbs and *Furmastix* Whitley 1951 (nomen novum for *Pluto* Hubbs, preoccupied), consequently enter into the synonymy of *Synbranchus*. It will be noted that I have based a separate genus for the Australian blind eel not on characters common to all cave fishes, but on the anterior position of the anus, a character that is unlikely to be directly connected with life in total darkness (as it is not found in *S. infernalis*, which lives under similar conditions).

Orientation

Very little can be said by me about the subject. All the "blind" species have probably lost their eyesight completely, which seems evident from the complete absence of pigmentation in the ocular region.

Nevertheless, some orientation must occur: particularly *Anommatophasma* has a habit of making straight for dark crevices when being disturbed out in the open of a well, and it seems likely that some kind of light perception exists. Tactile factors could hardly be involved in this kind of orientation. On the other hand it is well known that some other senses, like smell, are extremely highly developed in some fishes. Without experiments and anatomical investigations it will be difficult to decide if any perception of light still occurs in the species; light sensitivity (which is not sight) may well exist, it may be located in the pineal organ as is the case in other eyeless fishes, or in the eye-rudiments.

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Dr. M. Boeseman (Rijksmuseum van Natuurlijke Historie, Leiden), examined specimens of *Milyeringa*, and gave me his valuable opinion on their affinities; he also sent me on loan specimens of various species of Synbranchid eels. The manuscript was read by Drs. M. Boeseman, L. B. Holthuis and W. D. L. Ride, to all of whom I am indebted for useful suggestions.

To the keen interest of Mr. A. Snell we owe the information that with the discovery of *Milyeringa veritas* the subterranean fauna of Yardie Creek was not yet fully known. This not only led to the discovery by himself of the two species of shrimps, but ultimately also to our trip to the region and the capture of specimens of the remarkable *Anommatophasma candidum*.

Finally, both Mr. Douglas and I want to express our sincere gratitude to Mr. and Mrs. W. D'Arcy of Yardie Creek Station, who not only allowed us to come and stay with them and collect on the station but who also assisted in every possible way to make our trip the complete success it became. The same thanks have to be extended to Mr. E. Payne, owner of the station, who, unfortunately, we did not have the pleasure of meeting.

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